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FEDERAL COMMUNICATIONS COMMISSION  
OFFICE OF THE SECRETARY

Ms. Marlene H. Dortch  
Secretary  
Federal Communications Commission  
445 12th Street, SW  
Washington, DC 20054

Re: ET Docket No. 98-153

Dear Ms. Dortch:

The U.S. GPS Industry Council, through undersigned counsel, and pursuant to 47 C.F.R. Sections 1.415 and 1.419 of the Commission's Rules, offers the following overview comments on the FCC TRB Report.<sup>1</sup> Specific technical comments are included in Attachments to this letter.

### 1. Anecdotal Utility of FCC Test Measurements

While looking at the noise floor and at unintended emissions was interesting, we believe that these test measurements have only anecdotal utility in such an evaluation and no changes in the rules can be adopted based on these data. Consequently, this effort does not represent the serious testing required for fact-based rulemaking.

### 2. NTIA Methodology Provides Universal Basis for Regulation

By selecting background thermal noise, NTIA certainly used the only criterion that could be viewed as universal and appropriate for rulemaking. "To protect for this new GPS [E911] technology, NTIA proposed an analytically derived protection criterion based on the thermal noise floor of a typical GPS receiver. Specifically, NTIA recommended a receiver susceptibility mask based on constraining undesired UWB emissions to levels 6 dB below the thermal noise floor of a GPS receiver."<sup>2</sup>

The FCC TRB report proposes a new criterion that "... the ambient noise environment rather than the GPS receiver thermal noise density, may actually be the limitation to the reception of the low amplitude GPS signals".<sup>3</sup> However, the FCC test measurements to date of particular indoor

<sup>1</sup> FCC Project TRB 02-02 Report, "Measured Emissions Data For Use in Evaluating The Ultra-wideband (UWB) emissions limits in the Frequency Bands Used by the Global Positioning System (GPS)", October 22, 2002.

<sup>2</sup> *Id.* at 9.

<sup>3</sup> *Id.* at 32

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incidental noise, while interesting, are insufficient. Any set of measurements of a particular noise environment at any point in time does not provide average expected noise. Consequently, it would be futile to calculate the change in probability in effecting a successful mobile E911 call, either in terms of completing the call or having the location information. Clearly, if potential harm to public safety is to be determined by probability, this probability number should be known. The NTIA methodology provides a technically accepted universal approach. In the absence of exhaustive data collection and analysis, i.e., definitely not undersampled, a rational regulatory rule cannot be extrapolated from the current FCC anecdotal data. An exhaustive sample would involve thousands, if not hundreds of thousands of locations, with measurement sets giving noise levels by the minute for a 24-hour period. This assumes that the major variations are diurnal rather than a longer time period i.e., seasonal, which would complicate matters even further.

### **3. Utility Is In Managing Incidental Noise**

What the TRB report shows is that the FCC should be managing incidental noise to some fraction of the thermal noise level to preserve the utility of the spectrum. So, while this report provides a first step to modeling spectrum management of the incidental noise floor, it is insufficient for rulemaking particularly affecting safety-of-life and public safety.

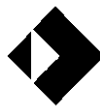
### **4. Unaddressed Testing: Operational Effect of Unlicensed Density**

The interference analysis that remains unaddressed is to measure the operational effect of actual unlicensed UWB devices and network density on the GPS noise floor.

In most intensely used communication channels, it is interchannel interference that is the limiting factor. This interchannel interference is noise created by dense operations. Unlicensed UWB devices, functioning either as point-to-point communication devices or as networks, will be operationally subject to interchannel interference limitations. How much noise aggregation from cooperative and non-cooperative networks operating in proximity will raise the overall noise floor is not yet known.

- **Darwinian Approach Fosters Jamming Frenzy Not Market Stability**

In the absence of operational testing of actual UWB devices and networks, attempting to expand the overlay of unlicensed frequency bands below 3.1 GHz continues to ignore the following unaddressed technical problems. In unlicensed bands today, there is no commitment to a single modulation or frequency use standard. We can expect that the incompatibility problems that arose in the 2.4 GHz bands will arise where there are competing standards and thus overlapping networks. The resulting Darwinian approach to dominance implies a jamming frenzy to determine the Last Man Standing. This will cause an additional, and potentially far greater damage, on the noise floor. To date, we have seen no fact-based data which would lead us to believe that any changes to the original Report and Order are warranted.



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The Commission cannot determine interference truth nor model true harm to the noise floor in the GPS band, without using actual UWB devices and networks in measurement tests to understand the operational interference effects. A predictive model of harm to the GPS noise floor cannot be based on unwanted incidental emissions from consumer devices that are not designed to operate in these bands and that do not operate as point-to-point communicators or in networks

While we support the advent of UWB communications and networks above 3.1 GHz as envisioned in the First Report and Order. In the absence of UWB industry agreement on a UWB communication and networking standard which defines the modulation and frequency use, no complete testing can be performed. If Darwinian survival is to be the relevant model, what will result then is a noise floor rise which is substantially greater than any given modulation technique.

### **Conclusion**

This test measurement of incidental noise floor represents an important first step in monitoring noise floor reality. However, these data are insufficient for fact-based rulemaking. Proceeding to any relaxation of the First Report and Order on UWB using this data instead of a universal technical criterion; receiver thermal noise density, will not provide a predictable or stable regulatory regime that fosters sustainable commercialization of technology. Promoting forced spectrum sharing without addressing the unresolved technical issues is authorizing a Darwinian approach.

Respectfully submitted,

Raul R. Rodriguez  
Counsel to U.S. GPS Industry Council

Attachments

## ATTACHMENT A

### Use of Anecdotal Data To Evaluate UWB Emission Limits Is Inappropriate

In interference analyses, you cannot compare items 1 and 2 with item 3:

1. noise produced by consumer devices (hair dryers, electric drills, vacuum cleaner) that:

- do not operate in the GPS bands
- operate geographically separate from communication and radio positioning services
- are incidental emitters
- unwanted emissions
- do not have an economic driver for communications
  - point-to-point
  - networking
  - no requirement intentionally to radiate maximum power
  - only occasionally emit at the maximum level at a few frequencies

2. ambient noise from electronics (printers, copiers, computers):

- do not operate in the GPS bands,
- are incidental emitters under Part 15
- unwanted emissions
- interference can be cured at the source
  - identified, located, isolated, shielded, turned off, removed

with

3. noise from unlicensed UWB consumer devices that

- are intentional emitters
- can be characterized as a broadband noise source that fills the spectrum
- current emission limits define OOB
- have an economic driver for connectivity
  - point to point communications
  - networking
  - have signaling structure that is introduced by their intended communications or ranging purpose
  - this signaling structure introduces line spectra

## ATTACHMENT B

Thermal noise is the correct approach to accounting for noise factors because it includes both the ambient noise temperature and the receiver noise temperature. They interact with each other and not in a linear way. The receiver noise temperature softens the effect of the ambient noise and sometimes dominates. One of reasons for the higher ambient noise indoors is the fact that the antenna is looking at the warm walls, instead of the cold sky. Walls are 3 or more times warmer (in absolute temperature) than the sky, resulting in 4 to 5 dB more ambient noise.

The equation for  $N_0$  in FCC TRB report is not correct for the noise floor. The equation only describes “receiver” noise – doesn’t include ambient source noise. The correct equation for thermal noise density, in dBW/Hz is

$$N_0 \approx 10 \log_{10} \left[ kT_s + kT_0 (10^{1NF} - 1) \right]$$

where  $T_s$  is the source temperature in K,  $k$  is Boltzman’s constant ( $1.38 \times 10^{-23}$  Watts/K-Hz),  $T_0$  is 290 K, and  $NF$  is the receiver noise figure in dB.<sup>1</sup> This source temperature is usually taken to be 100 K using an omni-directional antenna outdoors, accounting for ground clutter. This results in a source ambient thermal noise equal to -118.6 dBm/MHz. The source noise temperature would be 290 K indoors. When using a horn antenna such as was used in the FCC TRB report, pointed at the sky, the source temperature could be much lower because “ground clutter” is essentially eliminated. This explains ambient noise measured at -122 dBm/MHz. However, if the Sun is located in a narrow beam, the source temperature could be much higher.

For aviation applications, as derived by RTCA, a noise figure of about 4 dB is used as typical for including pre-filtering and lightning protection losses, thus the noise density (-111.5 dBm/MHz) is 7.1 dB higher than the ambient source noise density.

One might argue that for indoor and outdoor handheld or automotive GPS receivers, a lower noise figure is possible due to less stringent protection requirements than aviation. However, indoors, the lower noise figure is offset by a higher source temperature. An increase in source temperature of 2.9 (290 K instead of 100K) would require the noise figure to be reduced to 1.82 to achieve the same overall thermal density. This is quite low, so the conclusion is that the assumed noise density (-111.5 dBm/MHz) is universal.

The above equation does not include ambient radio noise (interference). The total noise density, including this interference (such as UWB emissions), is

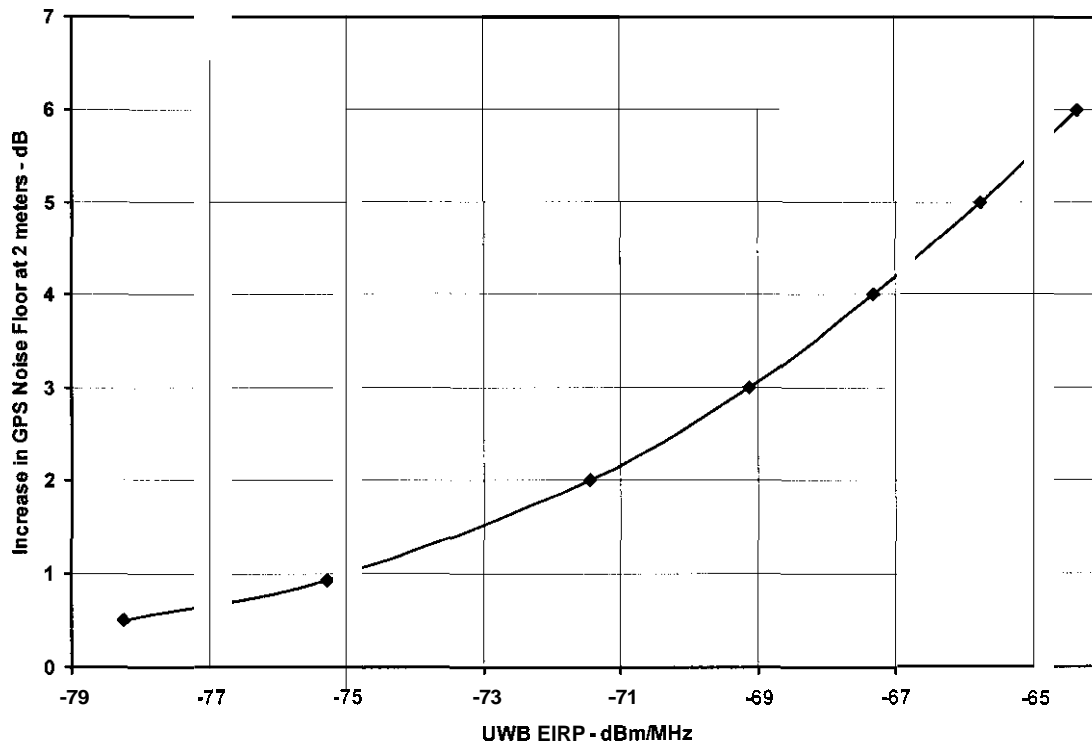
$$N_{0,\text{total}} \approx 10 \log_{10} \left[ kT_s + kT_0 (10^{1NF} - 1) + 10^{1N_I} \right]$$

where  $N_I$  is the interference noise density in dBW/Hz. To have a negligible impact, this interference noise density should be 6 dB less than the -111.5 dBm/MHz thermal noise density. Obviously, at 2 meters distance, the overall noise floor will be raised (about 1 dB for the NPRM emission level of -75.3 dBm/MHz). Figure 1 shows the increase in noise floor as a function of

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<sup>1</sup> B. W. Parkinson and J. J. Spilker, Jr., Editors, Global Positioning System: Theory and Applications I, Chapter 8, pp. 343-344, AIAA, 1996.

emission level. This increase in noise floor is consistent with that derived by the GPS Joint Program Office.<sup>2</sup>



**Figure 1. Raise in Noise Floor as a Function of UWB Emission Limit**

It is also important to note that this degradation in noise floor does not just apply to the GPS C/A Code. The same degradation also applies to the GPS military P Code.

We can only conclude that UWB emissions universally increases the noise floor for all GPS applications –indoors, outdoors and aviation, **and** conclude that the

We can only conclude that UWB emissions universally increases the noise floor for all GPS applications – indoors, outdoors and aviation, and conclude that the UWB emission limits cannot be raised above the already established -105.3 dBW/MHz limit.

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<sup>2</sup> B. M. Titus, et al, "Assessing Ultra Wideband (UWB) Interference to GPS Receivers," Paper presented at ION-GPS-2002, The Institute of Navigation, Portland, OR, September 24-27,2002,

## ATTACHMENT C

### Comments on “Measured Emissions Data For Use In Evaluating The Ultra-Wideband (UWB) Emissions Limits In The Frequency Bands Used By The Global Positioning System (GPS)” (ET Docket No. 98-153)

DA 02-2786, dated October 22, 2002

The following comments are provided on DA-02-2786A1:

1. The report exhibits bias in the use of the descriptor “extremely conservative emissions limits” when referring to the UWB emission limits defined to protect the GPS service using frequency bands allocated to safety-of-life use. Furthermore, the protection is for the European system Galileo as well as for GPS. This comment also applies to DA-02-2786A2.
2. Because unwanted ambient radio noise exists (due to unlicensed devices) in protected bands, we still have to limit the emission from devices whose intentional emissions completely cover the protected bands. Incidental devices do not intentionally emit in the protected bands.
3. ~~Part~~ of the reason why the ambient noise is higher indoors is that ambient temperature noise is higher indoors, independent of the ambient radio noise; another reason why we have to protect the indoor GPS devices.
4. It is not true that the Commission’s emissions limits were based on protection of GPS indoor operations. The Commission imposed the same emission limits out-of-doors for handheld and radar UWB devices to protect out-of-door uses of GPS.

The following comments are provided on DA-02-2786A2 (Project TRB 02-02 Report):

1. The First Report and Order (FCC-02-48A) derived the same emission limits for outdoor locations as for indoor locations. See page 25, paragraph 63, for vehicular radar systems, page 26, paragraph 67, for handheld UWB systems, again on page 64, paragraph 183, for both systems, and yet again on page 105, section 15.509, for low frequency imaging systems, and on page 107, section 15.513, for high frequency imaging systems, and on page 108, section 15.515 for vehicular radar systems, and on page 110, section 15.519, for handheld UWB systems.
2. The protection limits imposed on UWB emissions by the Report and Order (FCC-02-48A) are to ensure that the UWB emissions do not adversely raise the noise floor. (Even at the emission limits imposed, the noise floor is raised by about 1 dB over thermal noise at 2 meters.)
3. *These sites were selected primarily because GPS has been cited as a key navigational component for use in aviation, maritime, rail, and automotive transportation systems. Add the following: “, as well as E-911 and other applications used out-of-doors and under foliage canopies.”*
4. Many GPS receivers process bandwidths greater than 16 MHz – up to 20 MHz, especially those used in aviation and precision applications (ground and air).

5. When referring to authorized users who require greater precision, include civil GPS receivers that track the P code signal using codeless or semi-codeless techniques.

**6. It is also important to note that UWB emissions impact the GPS P code, and thus military users, as much as they impact civil C/A code users. The additional spreading of the higher chipping-rate P code does not increase the processing gain against wideband noise.**

7. Similar systems to WAAS are being developed in Europe and Japan, not planned. Also, LAAS *may* consist of terrestrial-based transmitters to augment GPS.

8. The fact that the actual GPS signal levels are known to be 7-10 dB greater than the minimum level is overstated – more like 3 to 5 dB. The Aerospace Corporation has written ION papers documenting this fact. However, the DoD will not guarantee those higher levels, so the GPS safety-of-life community can only rely on the -130 dBm level.

9. Because the GPS L1 band is within a restricted band of operation that is currently used exclusively for radio navigation satellite downlinks, there are no authorized frequency assignments to terrestrial-based systems. Therefore it is hypothesized that any existing emissions in the GPS L1 band will be a result of spurious (out-of-band and/or harmonic) emissions from intentional radiators, and/or low-level unintentional or incidental emissions from electronic and electrical devices, *i.e., no fundamental emissions are expected to be observed*. This is not true in the case of UWB emissions. UWB devices will generate fundamental signals in the protected bands and, if they are forced to, attempt to filter out the portion of the fundamental signal in the protected bands. UWB emission in the protected bands are not spurious (out-of-band and/or harmonic) emissions. If UWB emissions are not below the proposed limits, they will be observed.

10. With respect to the modernized L2 signal, it may be the C/A-code in the beginning, but will be the new L2C codes eventually, maybe earlier. This new signal is intended to be used by the E911 application once it is available on most of the satellites. Thus, this band must be protected, even though it is not used for aviation (except at protected ATC sites for WAAS using the P/Y code in a semi-codeless manner, but eventually using the L2C code).

11. Galileo also plans two signals at and near the L5 signal frequency. These signals must also be protected. It is not appropriate for UWB to overlay signals allocated to entities outside its jurisdiction.

12. DoD is only promising 5.1 dB higher L5 power (over L1 power) on the IIF satellites, and that is with respect to “guaranteed” signal level on L1, not actual.

13. It is not exactly true that the L5 signal is less susceptible to both noise-like and spectral line interference than the existing L1 signal, for two reasons. First of all, as it is for the P-code, the longer code signal is just as susceptible to broadband noise-like interference (like UWB) as the C/A code is. Second, the propagation loss at L5 is **2.54** dB less than it is at L1, so more of the UWB emission power will be observed at L5. This is also true for other interference at L5.

Furthermore, the stronger signal was specified to deal with DME and JTIDS interference and to accommodate more RF insertion loss due to “steeper” filtering requirements. The stronger signal is not available for UWB emission protection.

14. Thermal noise is the correct approach to accounting for noise factors because it includes both the ambient noise temperature and the receiver noise temperature. They interact with each other and not in a linear way. The receiver noise temperature softens the effect of the ambient noise and sometimes dominates. One of reasons for the higher ambient noise indoors is the fact that the antenna is looking at the warm walls, instead of the cold sky. Walls are 3 or more times warmer (in absolute temperature) than the sky, resulting in 4 to 5 dB more ambient noise.

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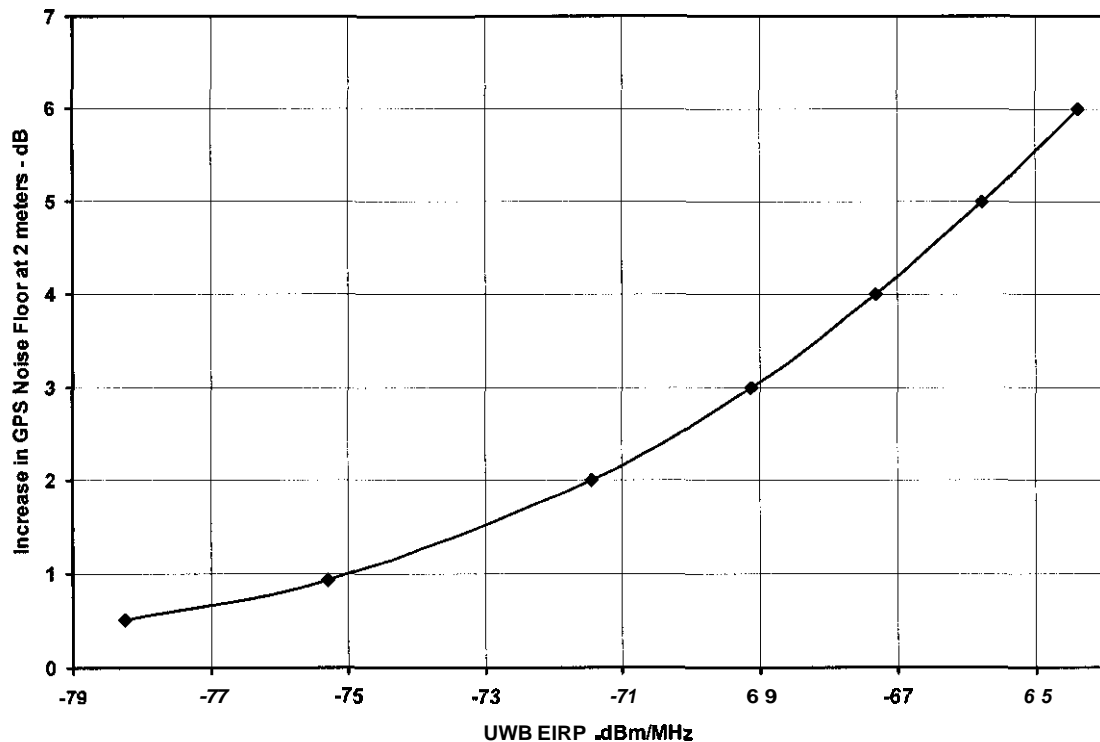
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**Figure 1. Raise in Noise Floor as a Function of UWB Emission Limit**

It is also important to note that this degradation in noise floor does not just apply to the GPS C/A Code. The same degradation also applies to the GPS military P Code.

We can only conclude that UWB emissions universally increases the noise floor for all GPS applications – indoors, outdoors and aviation, and conclude that the UWB emission limits cannot be raised above the already established -105.3 dBW/MHz limit.

16. At L2 this propagation loss decreases by 2.17 dB, and at L5 it decreases by 2.54 dB. Thus, the additional attenuation required increases by those amounts – all the more reason why the -105.3 dBW/MHz emission mask is so important, especially since, in the future, the L2C signal will be used for the enhanced GPS receivers.

<sup>2</sup> B. M. Titus, et al, "Assessing Ultra Wideband (UWB) Interference to GPS Receivers," Paper presented at ION-GPS-2002, The Institute of Navigation, Portland, OR, September 24-27, 2002,

17. Although the link budget is different for the non-indoor applications, the applicability of this proposed First Report and Order limit to those applications should be emphasized – this fact gets lost in this single sentence in this report. It should be emphasized in the Executive Summary as well.
18. The reported measured power spectral density levels are not necessarily all due to emissions. They are partially due, and sometimes all due, to the thermal noise background. For example, if indoors the antenna is pointed at a warm wall, the measured thermal noise level can be 3.5 dB higher than -117.5 dBm/MHz [ $10\log_{10}(290 \times 1.23 \times 10^{-23}) + 90$  dB for conversion to dBm/MHz = -114 dBm/MHz]. The distance to the wall doesn't matter. Similarly, in the outdoors environment, if the antenna pattern is not picking up much ground clutter, the thermal noise background could be significantly less (3 dB less if the sky temperature is 50 K instead of 100K). For example, the antenna with a relatively narrow beam pattern can be pointed directly towards different thermal backgrounds whose source temperature can vary widely – from a cold sky with no ground clutter outdoors to a warm wall indoors. Omni antennas, like those used on GPS, provide more consistency because of the larger viewing pattern.
19. What are described as ambient emission are actually ambient background and emissions, because thermal background noise is not an emission.
20. We fail to see how these measurement levels have anything to do with the emission limit applicable to UWB devices. The bottom line is that UWB emissions do raise the ambient noise floor – the primary reason for limiting emissions from UWB devices. If the UWB emission limit were increased to -65.3 dBm/MHz instead of -75.3 dBm/MHz, the noise floor in the GPS band would increase by an additional 5 dB. As it is, it increases by 1 dB at the -75.3 dBm/MHz level. See Figure 2 in B. M. Titus, et al, "Assessing Ultra Wideband (UWB) Interference to GPS Receivers," Paper presented at ION-GPS-2002, The Institute of Navigation, Portland, OR, September 24-27, 2002.
21. One flaw in the reported measurement process is the fact that some emissions (such as from DME or JTIDS at L5 with narrow high level pulses) can have high RMS values when integrated over 100 milliseconds, but do not affect GPS receivers as much as a wideband RMS noise level of the same magnitude. Of course, this is not true for UWB emissions that are "noise-like," although GPRs might fall in this category.
22. Stating that if each of the devices measured were subjected to the emission limits for UWB, most of the devices examined would fail a compliance test is analogous to the kid saying to his parents, "Joe down the street can do it, so why can't I?" The fact that these higher levels exist really says that the FCC didn't do their job to protect the GPS bands prior to this, and is all the more reason why UWB devices should be subjected to more stringent emission levels, so as to not add to the problem.
23. To imply that GPS receivers will commonly operate within 2 meters of an electric drill, a hair dryer or a vacuum cleaner is absurd and irresponsible, as compared to UWB devices.